

AS35-M36M and AS35-M20S Series

36-Bit Energy Harvesting Multi-Turn Absolute Encoder Module



Overview

The Broadcom® AS35-Mxxx series encoder is a high-resolution absolute encoder, which offers 20-bit optical single-turn and 16-bit multi-turn counts. On the other hand, a single-turn only encoder, with 20-bit resolution option is available. The AS35-Mxxx series encoder is a module encoder that consists of a patterned disk, a light source, and photosensitive elements to translate the mechanical motion into electrical signal. The AS35-Mxxx series encoder supports options of communication protocol, which is a half-duplex (2.5-Mb/s RS-485) or full-duplex (up to 10-MHz clock rate BiSS-C) with differential line transceiver, offering good noise immunity for more robust transmission in harsh industrial application.

The key advantage of the AS35-Mxxx series is its multi-turn tracking that employs energy-harvesting (EH) technology by harvesting the magnetic energy as the encoder shaft rotates. It is the gearless multi-turn counting that eliminates the gear wear-out or acoustics noise issues that are encountered in conventional geared multi-turn encoder. On the other hand, when comparing to battery backed up multi-turn counting, this technology does not require periodic maintenance of the battery backup components and avoid the down time associated with it.

Features

- Multi-turn encoder: 36-bit resolution with 16-bit energy harvesting multi-turn and 20-bit optical single turn
- Single turn encoder: 20-bit resolution optical single turn only
- Built-in communication protocol options: BiSS-C mode or RS-485 half-duplex
- Overall encoder outer diameter Ø35 mm and maximum height of 21 mm
- Supporting 6-mm shaft diameter
- 5 Kb of user accessible memory in EEPROM

Benefits

- No battery or capacitor required for position detection during power failure
- Immediate position detection
- upon power up

Applications

- Servo motors
- Scara or multi-axis robots
- Factory automation
- Linear positioning system
- CNC machine tool
- Medical and laboratory equipment

NOTE: This product is not specifically designed or manufactured for use in any specific devices. Customers are solely responsible for determining the suitability of the product for its intended application and solely liable for all loss, damage, expense, or liability in connection with such use.

Operating Theory

Structure wise, the encoder contains two main functional blocks, which are the single-turn optical engine block and the energy-harvesting multi-turn (EHMT) counter block. The single-turn engine comprises a Broadcom developed high-performance photodetector ASIC, coupled with a special multi-track code disk that rotates between the LED emitter and the photodetector ASIC.

On multi-turn side, the multi-turn counting uses the energy-harvesting technology. The beauty of the EH effect is that the same amount of energy is generated independent of the rotation speed. The generated energy is sufficient to power up the revolution tracking circuitry. Therefore, every revolution count is recorded even in the absence of external power supply.

Product Specifications

Electrical Specifications

Parameters	Conditions	Min.	Typ.	Max.	Unit
Current Consumption	Without load, $T_{amb} = 25^{\circ}\text{C}$	—	115	200	mA
Supply Voltage	—	4.5	5	5.5	V
Electrically Permissible Speed	—	—	—	10,000	RPM

Mechanical Specifications

Parameters	Conditions	Min.	Typ.	Max.	Unit
System Accuracy	$T_{amb} = 25^{\circ}\text{C}$	—	± 500	—	Arc-sec
	With electrical correction ^a , $T_{amb} = 25^{\circ}\text{C}$	—	± 80	—	Arc-sec
Mechanical Permissible Speed	—	—	—	10,000	RPM

a. Electrical correction requires a reference encoder system.

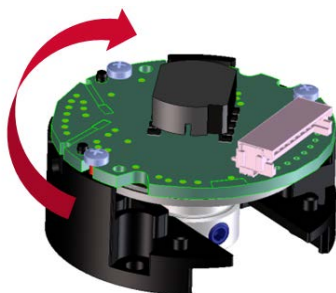
Environmental Specifications

Parameters	Conditions	Min.	Typ.	Max.	Unit
Storage Temperature	—	-20	—	105	$^{\circ}\text{C}$
Operating Temperature	—	-20	—	105	$^{\circ}\text{C}$
Relative Air Humidity (Non-Condensing)	$T_{amb} = 60^{\circ}\text{C}$	—	90	—	RH%
Vibration	Per IEC 60068-2-6	—	—	10G; 10~2000Hz	—
Shock	Per IEC 60068-2-27	—	—	6 ms; Half Sine; 200G	—
Electrostatic Discharge (Module level)	Per IEC 61000-4-2	—	—	2	kV

Encoder Specifications

Parameter	Remarks
Single turn Resolution	Single Turn 20 bits (0 to 1048575 counts)
Multi-turn Resolution	Multi-turn 16 bits (0 to 65535 counts)
Counting Direction	Increase with Clockwise (CW) motor shaft rotation, view from encoder top (Figure 1)
Initialization Time	500 ms
Alignment Method	After mechanical assembly of the encoder module and codewheel to the end system (for example, motor), an electrical signal alignment must be performed for optimum incremental to absolute signals. Refer to Application Note for more details.

Figure 1: Encoder Counting Direction



NOTE: Exposure to absolute maximum rating conditions for extended periods can affect reliability.

Interface Protocol: BiSS-C

Data Communication

Interface	Recommended Circuit
Serial Clock (MA)	Line Driver and Receiver Pairs (for example, P/N: SN65LBC179Q)
Serial Data (SLO)	Line Driver and Receiver Pairs (for example, P/N: SN65LBC179Q)

Encoder Timing Characteristics

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Notes
MA Frequency	f_{MA}	—	0.08	—	10	MHz	a
Busy	T_{busy}	$f_{MA} = 5 \text{ to } 10 \text{ MHz}$	$2/f_{MA} + 3.35 \mu\text{s}$	—	$2.5/f_{MA} + 3.75 \mu\text{s}$	μs	b
		$f_{MA} = 3.3 \text{ MHz}$	$13/f_{MA}$				
		$f_{MA} = 2.5 \text{ MHz}$	$10/f_{MA}$				
		$f_{MA} = 2 \text{ MHz}$	$8/f_{MA}$				
		$f_{MA} = 1 \text{ MHz}$	$5/f_{MA}$				
		$f_{MA} = 500 \text{ kHz}$	$3/f_{MA}$				
		$f_{MA} = 250 \text{ kHz}$	$2/f_{MA}$				
		$f_{MA} \leq 100 \text{ kHz}$	$1/f_{MA}$				

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Notes
Timeout	$t_{\text{BiSS-timeout}}$	—	$1.5/f_{\text{MA}}$	—	15,000	ns	b
Encoder initialization time	—	—	—	500	—	ms	—

a. MA low-time = $0.50/f_{\text{MA}}$; high-time = $0.50/f_{\text{MA}}$.

b. Refer to [Figure 2](#) and [Figure 3](#) for timing description.

Figure 2: MT Timing Characteristics of MA and SLO

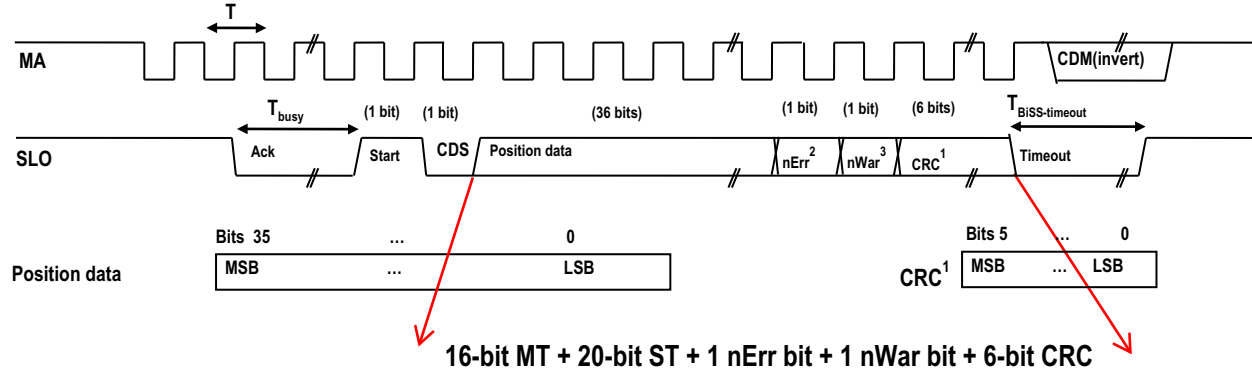
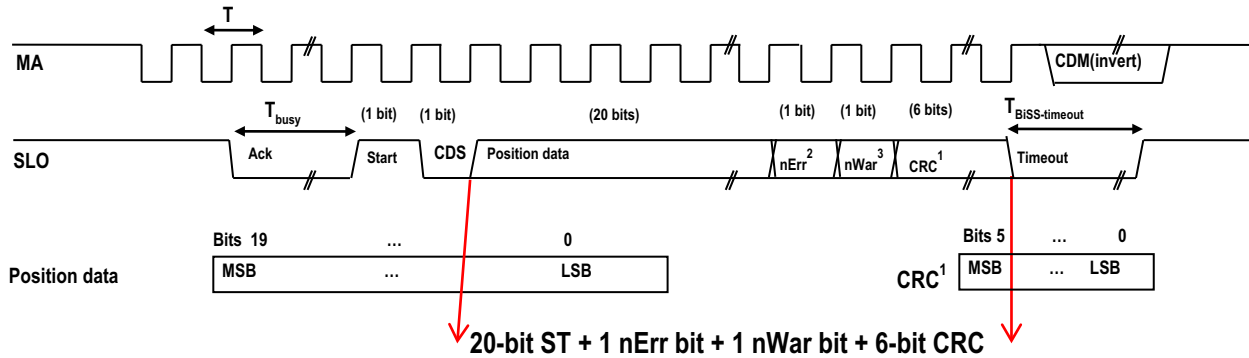


Figure 3: ST Timing Characteristics of MA and SLO



NOTE:

1. CRC Polynomial = Invert of $(X^6 + X^1 + X^0)$.
2. The nErr bit is active-low. (Combine all the Error Status and reflect it in nErr bit).
3. The nWar bit is active-low. (Combine all the Warning Status and reflect it in nWar bit).

Refer to the *BiSS-C Interface Protocol Description*, Rev. C5 document for detailed information of BiSS-C interface.

Memory Map

There are 10 register banks available as user areas (register bank 0 to register bank 9).

The memory data is kept in a non-volatile memory.

BiSS-C		Remarks
Bank	Address	
0	00h~3Fh	User area
1	00h~3Fh	
2	00h~3Fh	
3	00h~3Fh	
4	00h~3Fh	
5	00h~3Fh	
6	00h~3Fh	
7	00h~3Fh	
8	00h~3Fh	
9	00h~3Fh	
—	40h	Bank selection
	48h~77h	Client register (System Area, see Client Register Description)

NOTE: EDS bank is not supported.

Client Register Description

Address 72(0x48) – Error Status [7:0]

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3 ^a	Bit 2	Bit 1	Bit 0 ^a
N/A			MLSErr Error	Multi-turnErr Error	STErr Error	MemoryErr Error	XCErr Error

a. For ST option, Error Status Bit 3 and Bit 0 are N/A.

Address 73(0x49) – Warning Status [7:0]

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
N/A					TempErr Warning	LisErr Warning	LedErr Warning

Address 74(0x4A) – Encoder Clear Command

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 ^a
N/A				Warning clear command ^b	Error clear command ^b	ST clear command ^b	MT clear command ^b

a. For ST option, Encoder Clear Command Bit 0 is N/A.

b. Encoder Clear Command operation. Write 1 to execute one-time clear command. Only one command should be accessed each time.

Error Status

Bit	Alarm Status	Default value	Description
0	XCErr ^a	0	Multi-Turn Cross-Check Error. To indicate multi-turn block hardware miscount. 1: hardware miscount occur 0: no hardware miscount
1	Memory Err	0	To indicate EEPROM content loading status upon encoder power up. 1: Fail to load EEPROM memory data 0: Successfully load EEPROM memory data
2	STErr	0	To check integrity of ST position. 1: error in ST position 0: no error in ST position
3	Multi-turn Err ^a	0	To check integrity of MT position. 1: error in MT position 0: no error in MT position
4	MLSErr	0	To detect error in MLS (Mcode or the absolute code) generation. 1: error in MLS code detected 0: no error in MLS code detected
5	Reserved	0	Not used.
6	Reserved	0	Not used.
7	Reserved	0	Not used.

a. For ST option, Alarm Status Bit 3 and Bit 0 are reserved and not used.

Warning Status

Bit	Status	Default value	Description
0	LedErr	0	To indicate if LED current is out of operating range. 1: LED out of operating range. 0: LED within operating range.
1	LisErr	0	To check integrity of ADC Sine and Cosine signals by means of Lissajous specifications. 1: Lissajous out of specification. 0: Lissajous within specification.
2	Reserved	0	Not used.
3	Reserved	0	Not used.
4	Reserved	0	Not used.
5	Reserved	0	Not used.
6	Reserved	0	Not used.
7	Reserved	0	Not used.

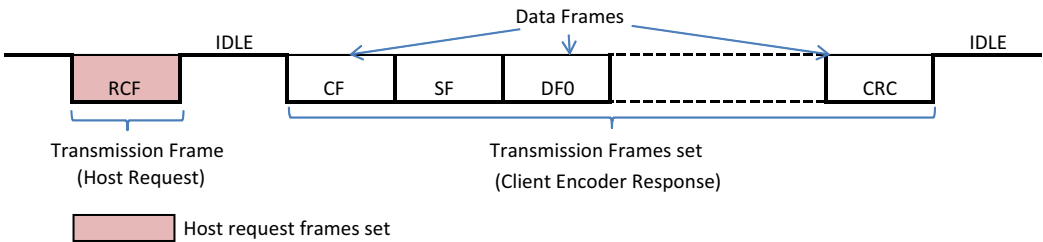
Interface Protocol: RS-485 Protocol

General Specification of RS-485 Serial Communication

Item	Specification	Note
Transmission type	RS-485 Compliant Differential Transceiver	—
Communication type	Half duplex	Recommended Transceiver: ISL8485E or Equivalent
Transmission Code Type	Binary, Non-Zero Return (NRZ) code	—
Synchronization type	Asynchronous	—
Communication Baud rate	2.5 Mb/s	—
Frame Length	10 bits/Frame	—
Transmission Error Checking	8-bits CRC	CRC equation $G(X) = X^8 + 1$ $X = CRC0 \sim CRC7$

A one-to-one half-duplex serial communication is established between the Client encoder and the Host (for example, a servo driver). The communication are in a differential transmission format that complies with RS-485 electrical standard. The encoder will carry out specific operations based on the command requests made by the Host. An acknowledgment of the command request is necessary before the encoder executes the requested operation, that is by checking the Start Bit, Information Data Field, and Stop Bit. Failing this checking, the encoder does not acknowledge and execute the received command request.

Figure 4: General Transmission Frames Format on Half-Duplex Line



Data Frames Content with Respective Command ID

Command ID	DF0	DF1	DF2	DF3	DF4	DF5	DF6	DF7
Command ID 0	STC0	STC1	STC2	—	—	—	—	—
Command ID 1	MTC0	MTC1	MTC2	—	—	—	—	—
Command ID 2	ENID	—	—	—	—	—	—	—
Command ID 3	STC0	STC1	STC2	ENID	MTC0	MTC1	MTC2	ERRF
Command ID 7	STC0	STC1	STC2	—	—	—	—	—
Command ID 8	STC0	STC1	STC2	—	—	—	—	—
Command ID C	STC0	STC1	STC2	—	—	—	—	—

NOTE:

- **STCn**: Single-turn counts, LSB of the single-turn counts are located in STC0 and MSB of the counts data are located in STC2. Combining STC0~STC2 provides total of 24 bits of single-turn data. For single-turn 20-bit encoder option, the higher 4 bits of STC2 is fixed to 0, hence giving total 20 bits of single turn-data.
- **MTCn**: Multi-turn counts, LSB of the multi-turn counts are located in MTC0 and MSB of the counts data are located in MTC2. Combining MTC0~MTC2 provides total of 24 bits of multi-turn data. For multi-turn 16-bit encoder option, the MTC2 is fixed to 00h, hence giving total 16 bits of multi-turn data.
- **ENID**: Encoder Single-turn bits identification. For single-turn 20-bit encoder option, the ENID is fixed as 14h.
- **ERRF**: Encoder Error Flags.

Error Flag (ERRF) Bits Definition

Bit Value	ERRF Bit							
	DF7-0	DF7-1	DF7-2	DF7-3	DF7-4	DF7-5	DF7-6	DF7-7
0	Not in use	Not in use	No Error	No Error	No Error	No Error	No Error	Not in use
1	Not in use	Not in use	Single-turn Counting Error	XC Error	Lissajous/ LED Errors	Multi-turn Counting Error	Memory Error	Not in use

EEPROM User Accessible Memory Area

Page [Decimal]	Address [Hex]	Remarks
0 to 4	0x00~0x7E	User Area
Page Selection	0x7F	

NOTE:

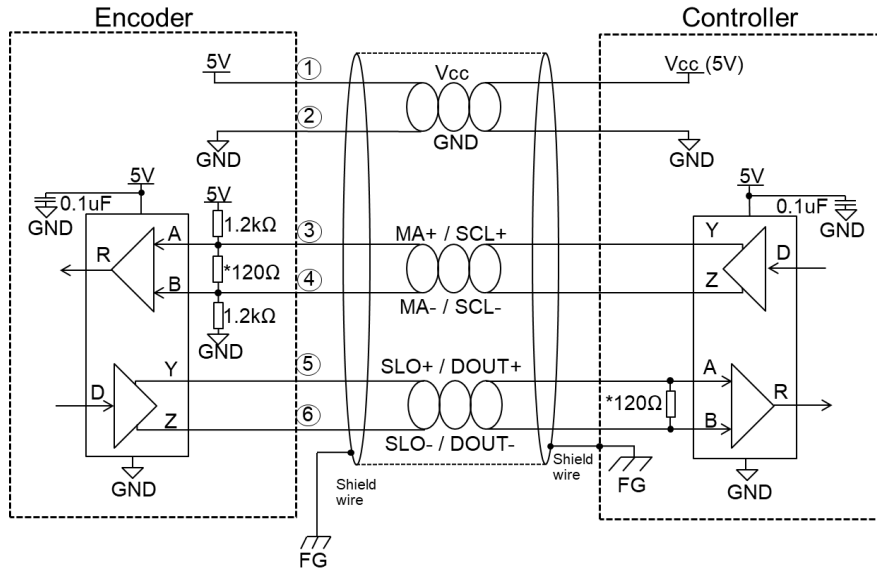
1. Total 5 banks with 127 addresses are allocated for user access.
2. All user-accessible addresses are preprogrammed to 00 prior to shipment.
3. The active bank numbers are specified in address 0x7F, the page change is done by writing to address 0x7F.

Interface Diagram

The following examples are of the circuit diagram of full-duplex and half-duplex transceiver.

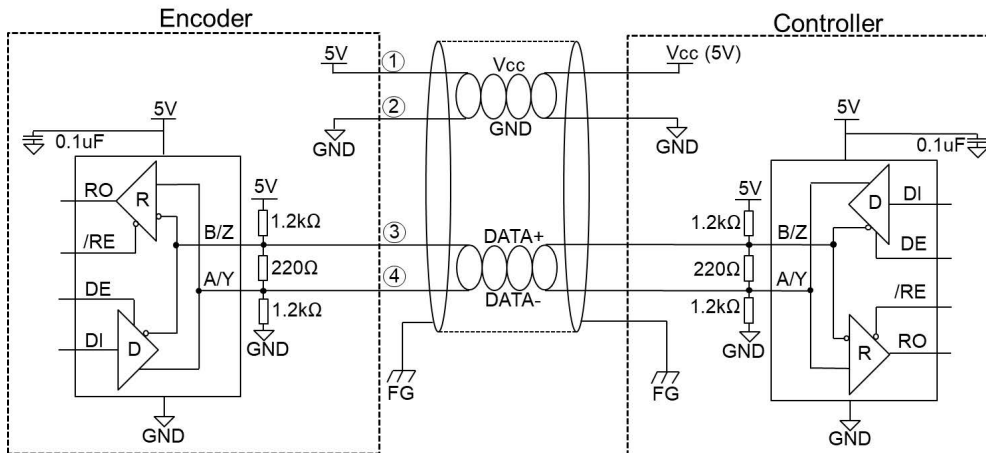
Full-Duplex Transceiver (BiSS-C Mode Protocol)

Figure 5: Recommended Circuit Diagram of the BiSS-C Full-Duplex Transceiver



Half-Duplex Transceiver (RS-485 Half-Duplex Protocol)

Figure 6: Recommended Circuit Diagram of the RS-485 Half-Duplex Transceiver



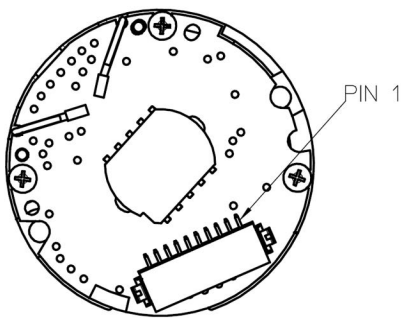
NOTE:

- Termination resistors, *120Ω and *220Ω, are recommended but it might depend on the characteristic impedance of the cable used.
- Twisted and shielded cables are recommended for better immunity in noisy environments.
- Depending on the application requirements, frame or chassis ground connection might be needed.

Connector Output Assignment

Pin	AS35-Mxxx-HxxB	AS35-Mxxx-HxxK
1	VCC, Positive Supply	VCC, Positive Supply
2	GND, Ground	GND, Ground
3	MA+	DATA+
4	MA-	DATA-
5	SLO+	Phase Calibration Signal 1
6	SLO-	Phase Calibration Signal 2
7	Phase Calibration Signal 1	Phase Calibration Signal 3
8	Phase Calibration Signal 2	Phase Calibration Signal 4
9	Phase Calibration Signal 3	N/A
10	Phase Calibration Signal 4	N/A

Figure 7: Pin 1 Indication for the Connector



***Recommended mating connector:**

- Hirose Part Number: DF13-10S-1.25C (CL No.536-0006-8)
- Hirose (Terminal Pin for Wire 26~30AWG): DF13-2630SCF (CL No.536-0300-5)

Mechanical Drawing

Package Dimensions

Figure 8: Package Dimensions for Multi-turn Option

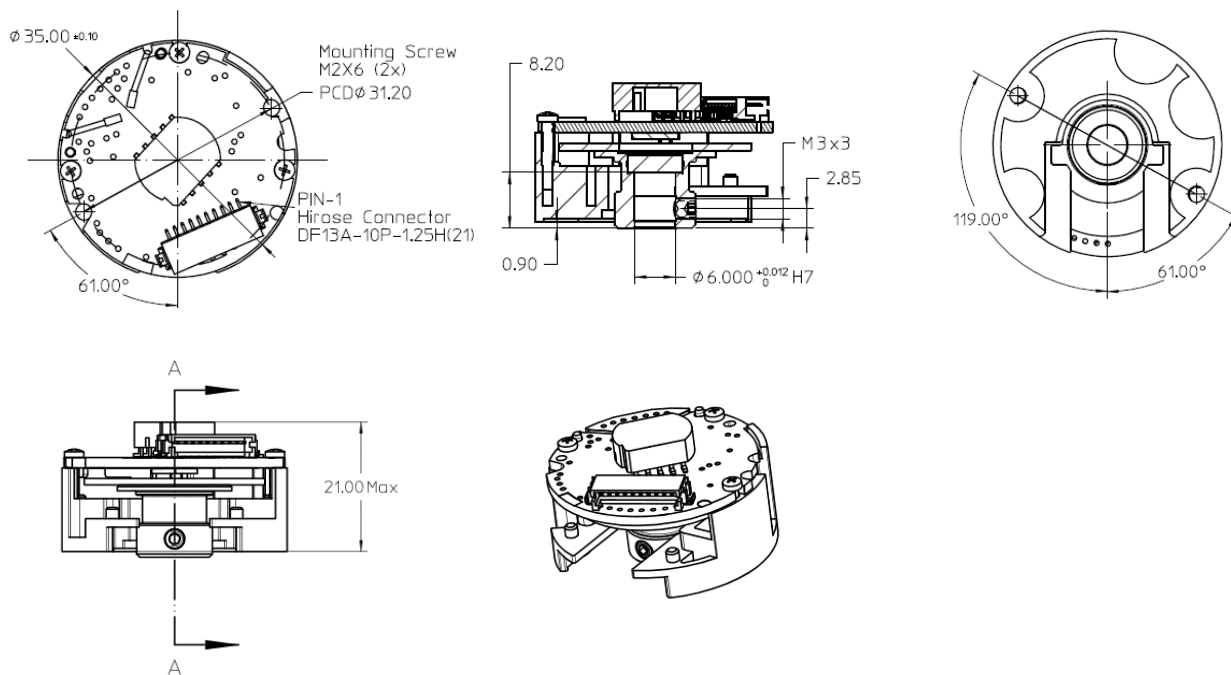
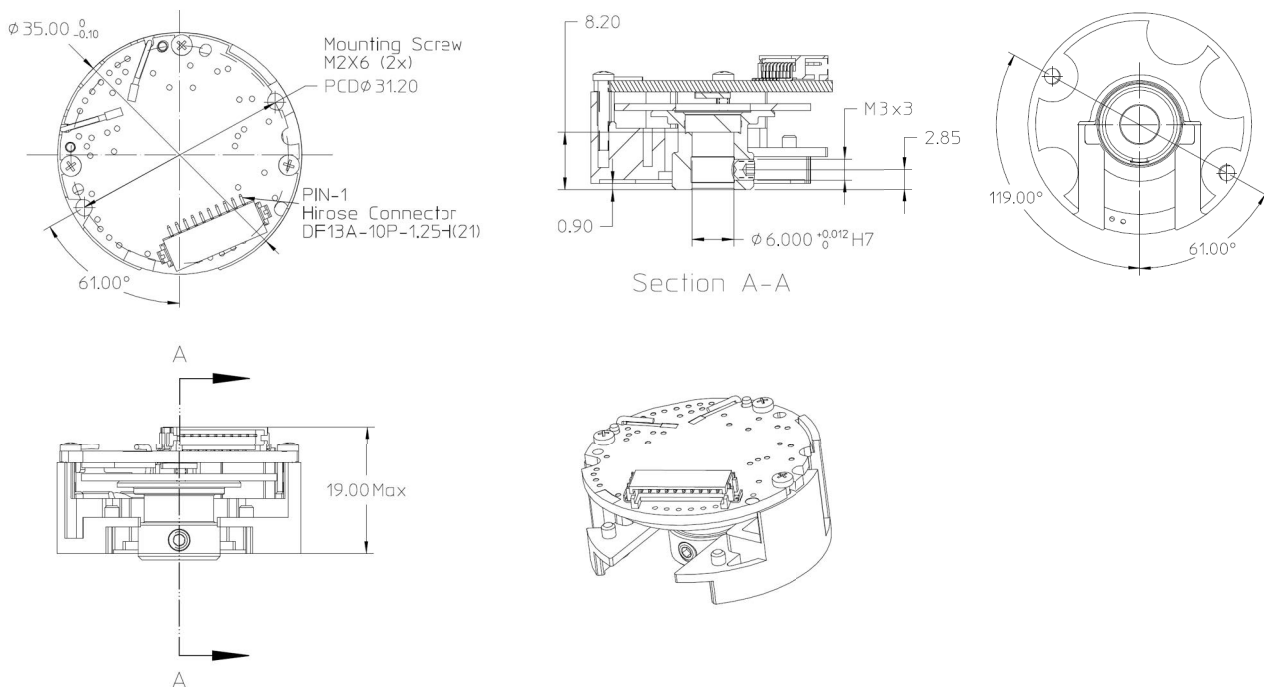
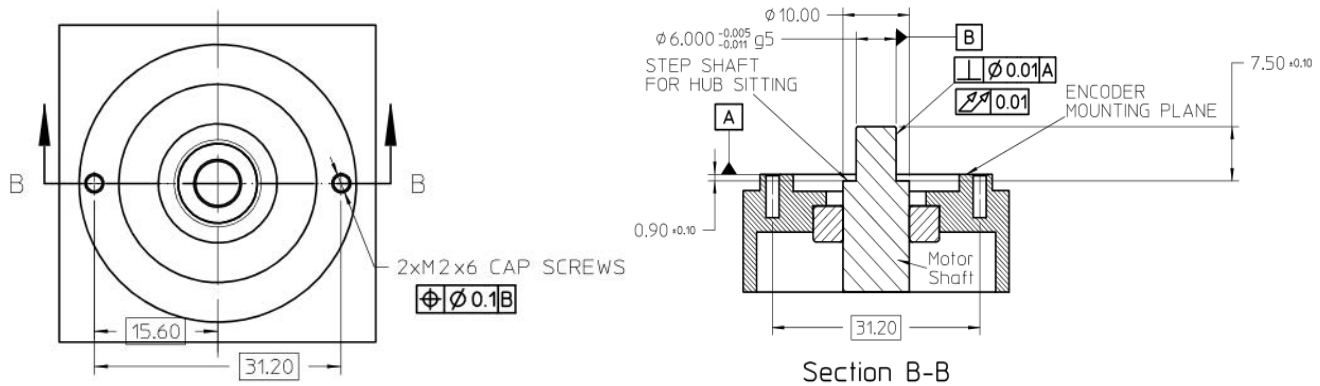


Figure 9: Package Dimensions for Single-turn Option



Shaft and Mounting Design Requirement

Figure 10: Shaft and Mounting Requirement

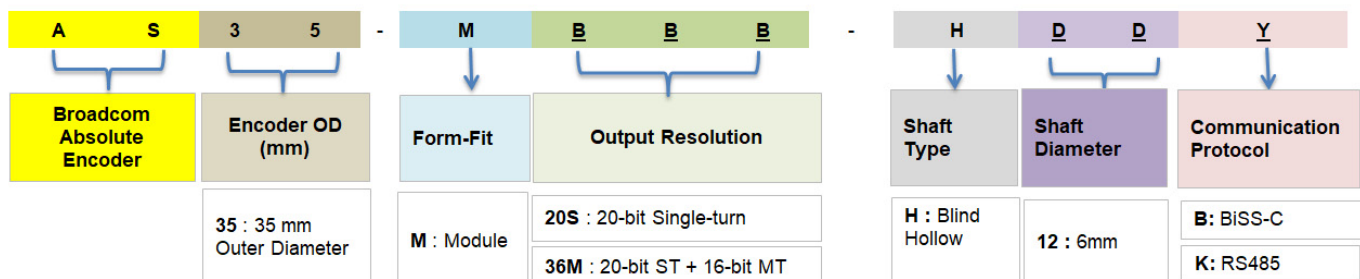


NOTE:

- Dimensions are in millimeters.
- Third angle projection.
- Unless otherwise specified, all tolerances are within ± 0.5 mm.
- Do not use ferromagnetic material for motor shaft.
- Metal shield is required for optimum operation of the Energy Harvesting counter. Refer to the AS35-M36M and AS35-M20S Series, Absolute Encoder Module application note for further details.

Ordering Information

Encoder



Accessories

- AS35-M36E-0010 Set Height and Radial Alignment Jig
- AS35-M36E-0020 Electrical Phase Calibration Set (RS485 Protocol)
- AS35-M36E-0030 Electrical Phase Calibration Set (BiSS-C Protocol)

NOTE: Refer to the factory for ordering samples and lead time.

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